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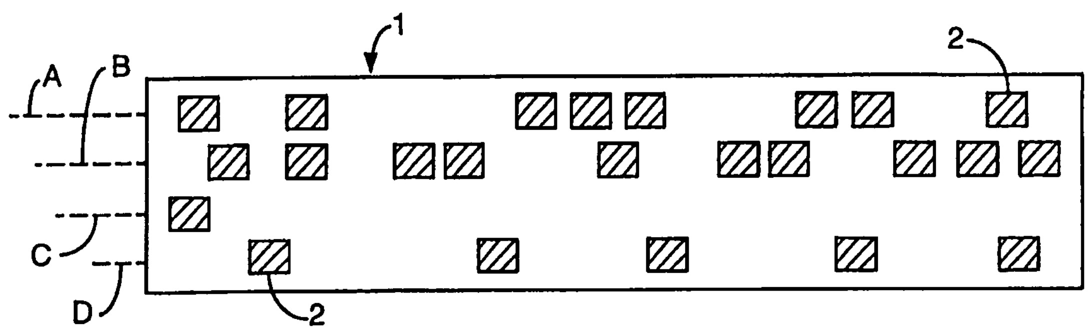

(57) Abstract

A multi-bit magnetic tag is disclosed which comprises a substrate (1) carrying a plurality of magnetised zones (2), the magnetic material from which said zones are formed being an anisotropic magnetic material having an axis of easy magnetisation; at least two of the magnetically active zones (2) are such that their easy axes of magnetisation are non-parallel. Tags of this form may be manufactured by sputtering a magnetically anisotropic material onto a substrate (1) carried on a coating drum while a non-uniform magnetic bias is applied to, or close to, the drum or the substrate (1) so as to influence the direction of the axis of easy magnetisation of the magnetically anisotropic material as it is deposited by the sputtering process. The coated substrate is then removed from the coating drum and cut into tags of the desired shape and size. Other multi-bit magnetic tags are also described.

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MAGNETIC TAGS AND TECHNIQUES

In previous patent applications, in particular PCT/GB96/00823 (WO 96/31790) and PCT/GB96/00367 (WO 97/04338), we have described and claimed novel techniques for spatial magnetic interrogation and novel magnetic tags. The technology described in WO 96/31790 is based on exploiting the behaviour of magnetic materials as they pass through a region of space containing a magnetic null. In particular, these earlier applications describe, inter alia, how passive tags containing one or more magnetic elements can perform as remotely-readable data carriers, the number and spatial arrangement of the elements representing information.

In the above applications we described a number of possible system embodiments employing either permanent magnets or electromagnets to create the magnetic null. We also described several system implementations some of which are particularly appropriate for tags employing very low coercivity, high permeability magnetic elements. These implementations work by detecting harmonics of a superimposed low-amplitude alternating interrogation field.

The present application relates to novel magnetic tags and to methods of reading magnetic tags.

According to one aspect of the present invention, there is provided a multi-bit magnetic tag which comprises a substrate which carries at least two magnetically active zones each formed of the same material and each of substantially the same shape and size.

Preferably a tag as just defined comprises from three

to twenty magnetically active zones; these may be arranged in a regular or irregular formation, e.g. in line along a strip-form tag; or as a two-dimensional array on a tag.

Data may be generated in a number of ways with such tags - for example, by one or more of the following: the number of magnetically active zones; their relative positions on the tag; the spacing between the magnetically active zones; and the intensity of magnetisation of the zones.

According to another aspect of the present invention, there is provided a multi-bit magnetic tag which comprises a substrate which is coated with a magnetic material carrying a plurality of magnetised zones spaced apart from one another by non-magnetised areas.

According to a third aspect of the present invention there is provided a multi-bit magnetic tag which comprises a substrate carrying a plurality of magnetised zones characterised in that the magnetic material from which said zones are formed is an anisotropic magnetic material having an axis of easy magnetisation, and in that at least two of the magnetically active zones are such that their easy axes of magnetisation are non-parallel.

With the third aspect as defined above, an additional source of data - namely the direction of the axis of easy magnetisation (hereinafter termed "DEAM") - is present in the tag. This may be used in combination with the variables described earlier in relation to the first embodiment. Also, it may be used in combination with isotropic magnetic zones to give further datum determinants.

Preferably a tag as just defined comprises at least three magnetised zones; these may be arranged in a regular or irregular formation, e.g. in line along a strip-form tag; or as a two-dimensional array on a tag. These magnetised zones may be spaced apart by non-magnetised areas, or they may be substantially adjacent, or they may be spaced apart by differently magnetised zones (although in such a case the intervening magnetic material will be chosen so as not to inhibit or corrupt the desired variation in DEAM).

Data may be generated in a number of ways with such tags - for example, by one or more of the following: the number of magnetically active zones; their relative positions on the tag; the spacing between the magnetically active zones; and the intensity of magnetisation of the zones.

According to a fourth aspect of the present invention, there is provided a method of making a tag as defined above, which method comprises sputtering a magnetically anisotropic material onto a substrate carried on a coating drum, characterised in that a non-uniform magnetic bias is applied to, or close to, the drum or the substrate so as to influence the direction of the axis of easy magnetisation of the magnetically anisotropic material as it is deposited by the sputtering process; removing the coated substrate from the coating drum; and cutting the coated substrate into tags of the desired shape and size. This permits tags with variable DEAM to be manufactured by sputtering techniques utilising a magnetic bias during the sputtering operation. The magnetic bias may, for example, be associated with the cooled drum carrying the substrate onto whose surface a magnetic alloy is being deposited. In one technique for producing such

tags, a spatially alternating magnetic bias magnet is positioned beneath the surface of the drum. A suitable bias magnet for this purpose is one formed of a flexible polymeric material containing magnetisable particles, e.g. ferrite. These flexible sheets can readily be magnetised according to any desired pattern of magnetisation, and so more complicated patterns may be generated if desired.

During normal sputtering of anisotropic magnetic materials using a rotating cathode and either conventional or rotating magnetrons, the DEAM extends across the width of the film which is being produced. By placing a permanently magnetised sheet with a regularly varying pattern of magnetisation behind the coating drum, the sputtered material experiences varying magnetic environments as the drum rotates. Where the magnetisation behind the drum is very low or zero, the sputtered material will have its DEAM aligned across the width of the web, as normal; as the underlying magnetic field increases, it will progressively influence the environment at which deposition occurs, resulting in the DEAM swinging around from its "zero point" direction to a new direction whose vector depends upon the magnetisation direction underlying the drum. By using a bias magnet which has bands of alternating field direction, the DEAM of the sputtered web can be made to rotate as the web is produced. The rotation is not uniform, however, since a certain field strength is required before the deposited material "flips" away from its zero point DEAM.

It is also possible to use magnetic bias means positioned outside the drum, provided care is taken to prevent problems arising with the magnetrons used in

the sputtering process.

According to another aspect of the present invention, there is provided a method of reading data stored in a magnetic tag, which comprises subjecting the tag to a relatively large substantially static magnetic field which progressively reduces to zero; and, at least when the said magnetic field is at or approaching zero, subjecting the tag additionally to a relatively low amplitude alternating magnetic field; and detecting the response of the tag when the substantially static field is at or in the vicinity of its zero point and the tag is experiencing the alternating magnetic field.

The substantially static magnetic field will usually be a DC magnetic field; it could alternatively be a slowly changing field, as for example would be obtained if two electromagnets generate the field and are fed with ac of say 1 Hz or less.

The invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows a plan view of one tag in accordance with this invention;

Figure 2 shows a plan view of another tag in accordance with this invention;

Figure 3 shows a plan view of a third tag in accordance with this invention;

Figure 4 shows a magnetic biassing means for use in generating tags with variable DEAMs; and

Figure 5 illustrates how the DEAMs vary in dependence

on the properties of the magnetic biassing means of Fig. 4.

In the tags of Figures 1-3, the tag comprises a substrate 1 which carries a plurality of magnetically active zones such as 2.

In Figures 1 and 2, each zone of magnetically active material is formed of the same material and has substantially the same shape and size. The zones in Figure 2 form a simple liner array, while those of Figure 1 are arranged in four linear arrays indicated by dashed lines A, B, C and D.

Figure 3 shows two of a series of identical tags produced from a web 4 obtained from a sputtering machine which is operated with magnetic biassing means underlying the coating drum. The arrows show the DEAM for each of the zones; as shown, zones 2, 3a, 3b and 3c have different DEAM. The gaps 6 between the magnetically active zones can be formed by modifying the magnetic properties of the sputtered material during or after the sputtering process.

Figure 4 shows a magnetic biassing means for use in producing tags having variable DEAMs. The means consists of a flexible polymer sheet incorporating fine particles of ferrite which are magnetised in alternating field directions F_1, F_2, F_1, F_2, etc. as shown.

The resultant web of sputtered material is shown in Figure 5. Here, the dashed and chain lines E, F and G are used to correlate field directions F_1 (line E), F_2 (line G) and zero field (line F) in the magnetic biassing sheet with the resultant DEAMs K, L and M in

the sputtered web. Cutting such a web into thin strips produces a series of strip labels whose characteristics resemble those of Fig. 3, but with a more regular variation of the DEAM.

The invention is not restricted to the embodiments described above, which are given as a non-limiting examples.

CLAIMS:

1. A multi-bit magnetic tag which comprises a substrate carrying a plurality of magnetised zones characterised in that the magnetic material from which said zones are formed is an anisotropic magnetic material having an axis of easy magnetisation, and in that at least two of the magnetically active zones are such that their easy axes of magnetisation are non-parallel.

2. A tag as claimed in claim 1, characterised in that the tag comprises at least three magnetised zones.

3. A tag as claimed in claim 1 or 2, characterised in that said magnetised zones are spaced apart from one another by non-magnetised zones.

4. A method of making a tag as claimed in claim 1, which method comprises sputtering a magnetically anisotropic material onto a substrate carried on a coating drum, characterised in that a non-uniform magnetic bias is applied to, or close to, the drum or the substrate so as to influence the direction of the axis of easy magnetisation of the magnetically anisotropic material as it is deposited by the sputtering process; removing the coated substrate from the coating drum; and cutting the coated substrate into tags of the desired shape and size.

5. A method according to claim 4, characterised in that a spatially alternating magnetic bias magnet is positioned beneath the surface of the coating drum during the sputtering operation.

6. A method according to claim 5, characterised

in that said spatially alternating magnetic bias magnet is formed of a flexible polymeric material containing magnetisable particles, e.g. ferrite, which have been magnetised to give the desired bias pattern.

7. A method of reading data stored in a magnetic tag, which comprises subjecting the tag to a relatively large substantially static magnetic field which progressively reduces to zero; and, at least when the said magnetic field is at or approaching zero, subjecting the tag additionally to a relatively low amplitude alternating magnetic field; and detecting the response of the tag when the substantially static field is at or in the vicinity of its zero point and the tag is experiencing the alternating magnetic field.

Fig.1.

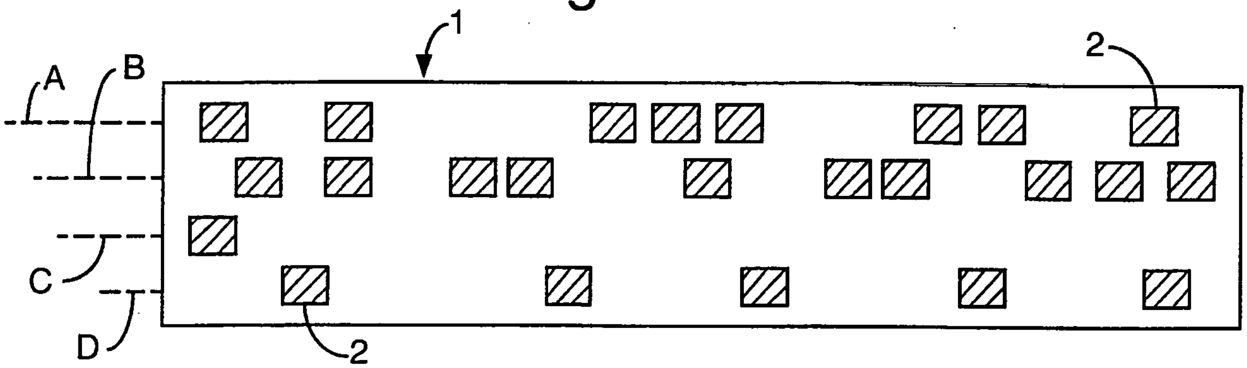

Fig.2.

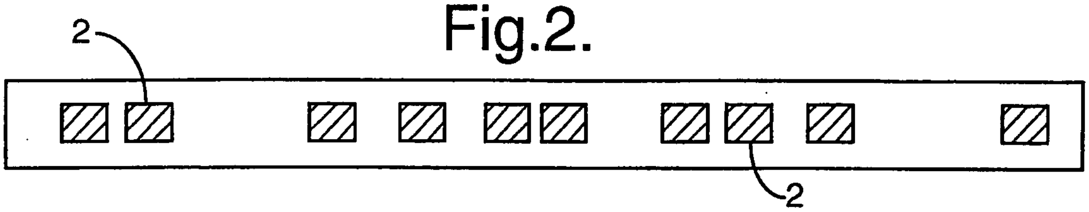

Fig.3.

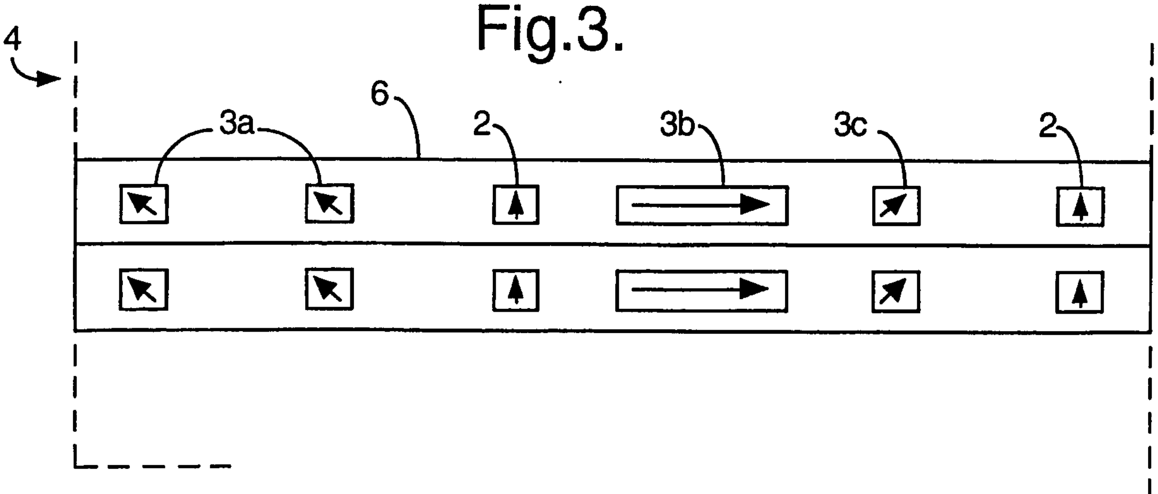

Fig.4.

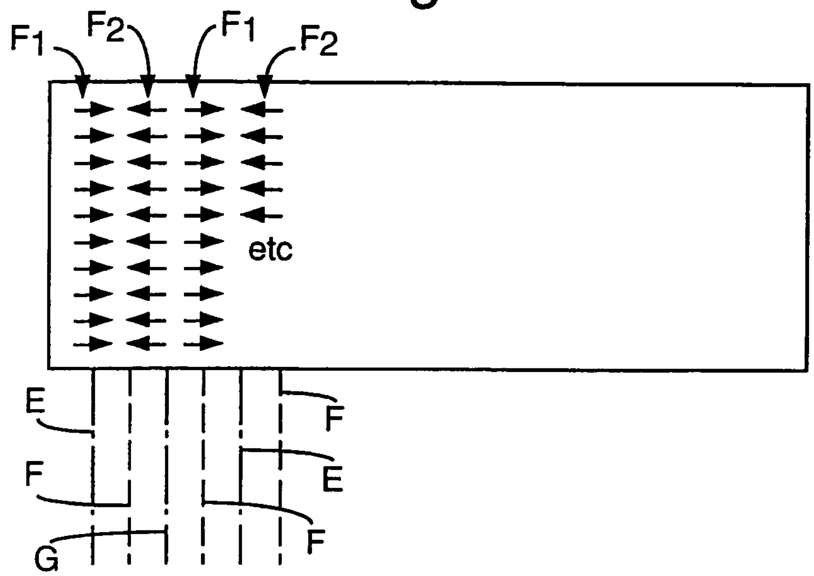

Fig.5.